

## **CERGOP-2/ENVIRONMENT, COMPLETION AND FUTURE ASPECTS**

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### **ABSTRACT**

The project "CERGOP-2, a multipurpose and interdisciplinary sensor array for environmental research in Central Europe" was approved by EC within the 5th Framework Program and started April 1st, 2003. It was officially terminated October 31, 2006 (amendment 3 and 4) and financially closed end of 2007. The results of 17 work packages were published in the Reports of Geodesy, Warsaw University of Technology, Poland comprising altogether more than 3600 pages.

On behalf of 14 contractors I give a summary of the current results which concern, for the area of investigation (15 % of Europe), a high quality GPS network operational for the next decade, velocity field and strain maps for geodynamical investigations and hazard mitigation, data for climate research and weather forecast, data for real time navigation and a seamless data bank for scientific and public access. The results are based on partly continuous GPS measurements at up to 80 permanent stations carried out during the last 14 years.

In addition, I try to give a future perspective for the investigations to be done during the next decades which aim at the understanding of the internal forces being the reason for plate kinematics which formed the present shape of the earth surface during the last billion of years. Hopefully next generations will be able to forecast sudden changes of the earth surface including the necessary energy transfer leading to earth quakes and to give valuable support for risk management and mitigation procedures.

### **1. SHORT EXPLANATION OF THE PROJECT**

**CERGOP-2:** Continuation of CERGOP defined 1992 as a joint project of the Central European Initiative (CEI) by Hungary. CERGOP means: Central European Regional Geodynamic Project. This project was prolonged 1998 in Wettzell and re-named as CERGOP-2. It mainly uses GPS for a steady monitoring of the earth surface within **CEGRN** plus additional terrestrial measurements like absolute gravity and others.

**CEGRN:** Central European regional GPS Geodynamic Reference Network proposed 31. July 1992 by Hungary. The CEGRN consortium was signed in Budapest, September 2001, it was the basic body for the project. CEGRN delivers the main data-input for long term determination of station coordinates and their inclusion in time-series. This task is a "never ending story".

It mixes long term secular influences (Geo-Kinematics) with “short” term effects (local earth-quakes, landslides, space weather, troposphere and other environmental impacts like sea-rise and sea surface topography)

**ENVIRONMENT:** Information about rapidly changing parameters like: sudden changes of coordinates (earthquakes, land slides, etc.); temporary changes of the ionosphere (space weather, etc.); local changes of the troposphere (change of water-vapour content affecting GPS height determination, ground meteo values); forecast and hazard mitigation (coordinated with other geo-sciences)

**ABSTRACT OF THE AGREED SECOND PROPOSAL:** Hard/software facilities in 13 countries of Central Europe will be updated to an interdisciplinary multi-purpose GNSS sensor array for environmental monitoring. Data acquired during the last 8 years will be supplemented, a continuous monitoring will be ensured during the next decade. Products are weekly coordinates, hourly zenith delay estimates and discrete values for epoch stations. Analysis of long term coordinate time series allows for the monitoring of crust movements; velocity fields, geo-kinematical models and strain fields will be used as the basis for geodynamic investigations like force models for the physics of dynamic processes and energy transfer (earth-quake prediction). Regional campaigns will investigate seismic active regions for hazard detection and possible mitigation. Hourly zenith delays are input for European weather forecast models. A seamless data bank will provide data/results for navigation, precise positioning, and scientific/public use in near real time.

## 2. PROGRESS OF THE PROJECT AND FINANCIAL CLOSURE

### Start of the project:

15.06.1999: 1st trial -> rejected  
15.10.2001: 2nd trial received a „go“  
01.04.2003: Official start of the project

Duration: 3 years until 31.03.2006

Money allocated in total: € 2,748.423  
To be refunded by EC: € 2,045.319

Changes: FC (50%, Overhead actual), FF (50%, Overhead 80%), AC (100%, Overhead 20%)

Official project meetings:  
Kick-off (Graz), 3 annual symposia (Nice and Vienna), 3 semi-annual meetings (Warsaw, Sofia, Sarajevo)

### End of the project:

31.03.2006: Official end after 3 years  
31.07.2006: Prolonged by 4 months (2)  
31.10.2006: Prolonged for financial reasons (4).

November 2007: Final payment received

January 2008: All money distributed

Money refunded by EC: € 1,768.221

Project meetings during prolongation:  
Final meeting (Graz), 1 annual EGU symposium (Vienna)

Post meetings: 2 EGU symposia (Vienna), CEGRN-Meeting (Graz)

Money flow for the whole project:

Contractor	Applied:	Status	Agreed by EC:	%	Paid by EC:	%
Austria	337.595	FC	173.515	51	161.186	93
Germany	312.811	AC	312.740	100	343.783	110
Italy (ASI)	593.620	FF	296.310	50	274.815	93
Italy (Padova)	286.522	AC	186.938	100	139.992	75
Bulgaria	138.912	AC	138.175	100	96.350	70
Czech Republic	156.316	FC	78.292	50	83.457	107
Hungary	232.913	FC	116.700	50	130.280	112
Poland	204.000	AC	203.984	100	100.505	49
Romania	118.581	AC	118.494	100	89.874	76
Slovakia	125.275	AC	124.758	100	89.874	67
Slovenia	121.770	AC	119.354	98	96.586	81
Croatia	85.744	FC	42.874	50	88.969	208
Ukraine	89.280	AC	89.704	100	30.825	34
Bosnia&H	45.084	AC	45.045	100	48.351	107
<b>Total:</b>	<b>2,748.423</b>		<b>2,045.319</b>		<b>1,768.221</b>	<b>86.4</b>

### 3. AMENDMENTS AND FINAL FINANCIAL ASPECTS

**Amendment 1:** Required for changing the responsibility of the German partner from UBW (University der Bundeswehr, Munich) to THDAR (Technical University of Darmstadt) and the change of the Bulgarian partner to another institute within the Bulgarian Academy of Sciences).

**Amendment 2:** The coordinator applied for a prolongation of the project for 3 to 6 months. EC agreed to prolong the project for 4 months until July 31, 2006.

**Amendment 3:** A new proposal was made to include the costs for prolongation, reducing the total sum to be paid by EC but including all requests for the final (prolonged) period. This also enabled to include costs above the limitations placed for the original project definition per contractor (see all values above 100%) which were defined and accepted five years earlier.

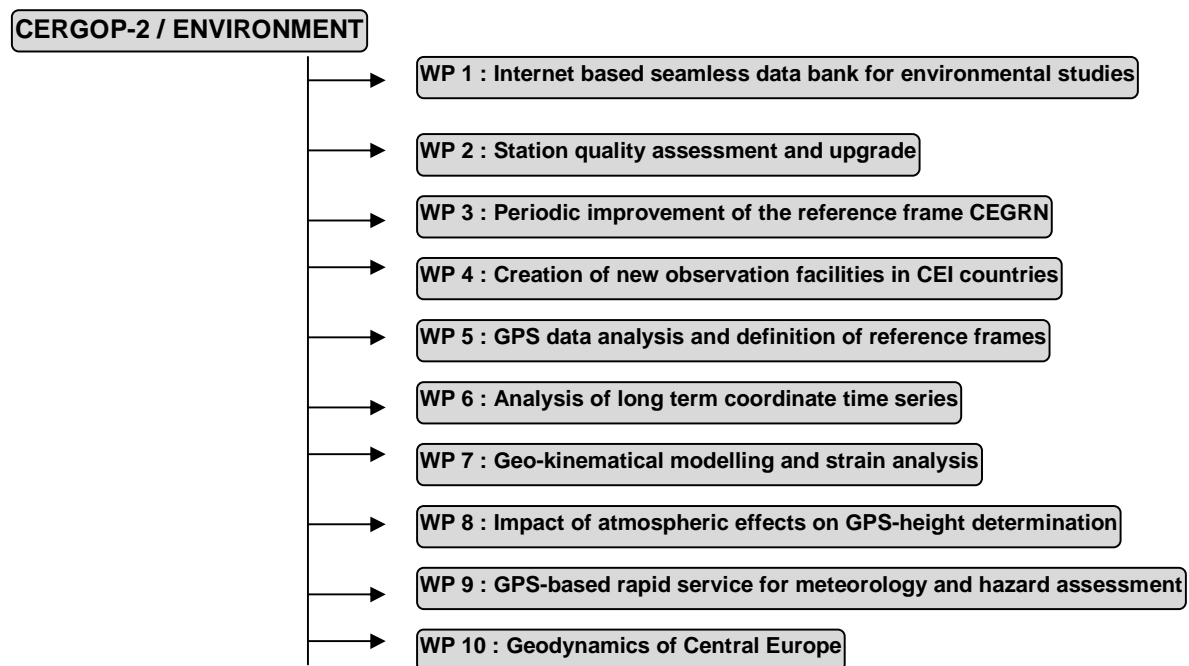
**Amendment 4:** Required to include the printing costs of Warsaw, prolongation until 31.10.2006.

**Proper use of allocated money:** According to the table describing the money flow we have 3 categories (last column). Five partners (>100%) received more money than agreed at the project start, six partners (>70%) used the allocated money somehow properly, 3 partners (<70%) really missed the opportunity to provide valid bills to be accepted by EC.

In particular, they did not use the chance to buy equipment in the first project year relying on the fact that depreciation of equipment costs was not confirmed by EC during the first project year. Only a personal contact in Brussels March 2005 could clarify the situation. One problem remains: The partner Ukraine only used 34% of the allocated money. As 40% were advanced at project start the sum of € 5.056 remained in Ukraine and cannot be refunded. The CEGRN-consortium decided in Vienna, April 2008, that all partners will return this sum to the coordinator according to the percentage of received money. By now, Austria and Romania reacted.

#### 4. SCIENTIFIC PROGRESS SPLITTED IN WORK PACKAGES

10 work-packages and 7 sub-packages were included in the project. All 17 packages brought reasonable results and should be continued on a long term scale. The results were published mainly in the Reports on Geodesy of the Warsaw University of Technology (RGW) and comprise nearly 4000 pages. The basic final output can be found in: RGW No. 3(78), 2006 (Final conference in Graz 2006); Journal of Geodynamics, 45 (2008), 246-256 (accepted Jan 10, 2008); RGW Proceedings of the yearly EGU symposia in Nice and Vienna; RGW reports of the semi-annual conferences in Warsaw, Sofia and Sarajevo.



##### Work package 1:

**Responsible:** Austria; **Task:** Establishment of a seamless data-bank for scientific and public use.

**Final output:** Creation of the CEGRN data bank; In addition: EUREF back-up data centre. Continuous update and improvements.

**Work package 2:**

**Responsible:** Hungary; **Task:** Standards at high level; Local site stability for CEGRN; LS monitoring; CEGRN development.

**Final output:** Site catalogues; frequency tests; de-correlation of local influences; checking of obstructions. Visit of most of the CEGRN sites.

**Work package 3:**

**Responsible:** Hungary and all; **Task:** Systematic GPS measurements (WP2); 1 week per 2 years at all CEGRN sites; Inclusion of epoch sites. Data and protocols sent to the CEGRN data centre.

**Final output:** Promotion of permanent stations ! GPS-raw data for computations; Station protocols; Met-data for height determination improvement.

**Work package 4:**

**Responsible:** Germany; **Task:** Development of a universal low priced multi sensor permanent observation facility for long term observations. Deployment of prototype stations in CEI countries.

**Final output:** Prototype of a multi sensor station (fixed version); Prototype of a multi sensor station (mobile version); Technical report describing all components, software, test results and error budget.

**Work package 5+7:**

**Responsible:** Slovakia; **Task:** Definition, mathematical model, practical realisation and maintenance of a geocentric reference frame. Modelling of the regional velocity field and strain analysis.

**Final output:** Coordinates and velocities; Zenith delays; Transformation parameters; Graphical information. Time series for permanent stations and snapshots.

**Work package 6:**

**Responsible:** Padova, Italy; **Task:** Analysis of long-term coordinate time series for the elimination of time dependent local effects; Way to derive velocities, geo-kinematics modelling and strain analysis (WP7).

**Final output:** Procedures generating at regular intervals plots which describe in the time and frequency domain the noise structure of the coordinate time series of the permanent stations; Maps included.

**Work package 8:**

**Responsible:** Czech Republic; **Task:** Development of relevant models of the troposphere for improving GPS height determination and placing adequate local data (humidity) for weather forecast.

**Final output:** Check of different models in alpine regions (large height differences) and improvement of GPS height determination.

**Work package 9:**

**Responsible:** ASI, Italy; **Task:** Near real time prototype service based on regional GPS networks for meteorology. Monitoring and hazard assessment of areas affected by ground instabilities and flood, coastal erosion.

**Final output:** Zenith troposphere delays for 63 stations in the central Mediterranean area; 100 station network in post processing mode; Landslides monitoring in southern Italy plus strain rates calculation.

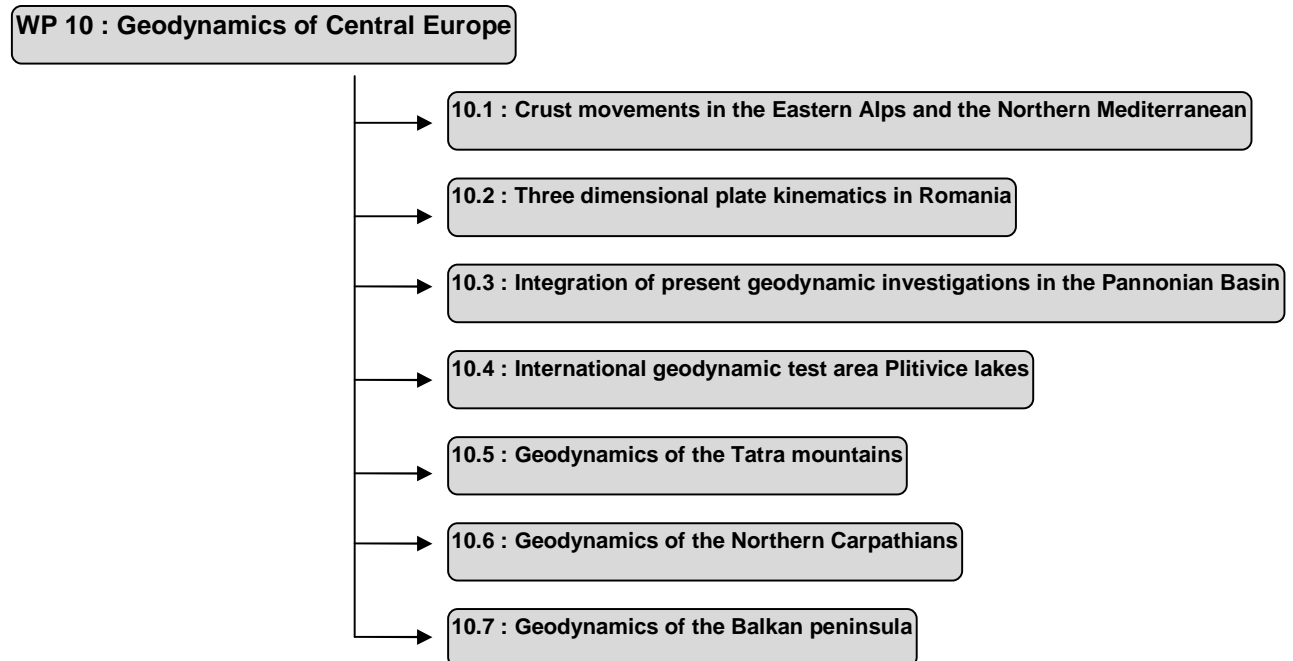
**Work package 10:**

**Responsible:** Poland, Czech. Rep.; **Task:** Monitoring of recent crust movements (see WP 10.1 to 10.7); Supervision of the sub-groups Eastern Alps/ Adriatic Sea, Pannonian Basin, Plitvice Lakes, Tatra Mts., Vrancea region, Carpathians, Balkan Peninsula.

**Final output:** 2 working meetings per year in Prague; 7 sub packages coordinated; Completely described in: “Current status of geo-tectonic investigations in Central Europe”, RGW No. 4(79), 2006, 461 pages.

Partially described in: Proceedings of the final CERGOP-2/Environment conference in Graz, RGW No. 3(78), 2006, 305 pages

**Sub-packages 10.1 – 10.7 administrated by WP 10:**



**Work package 10.1:**

**Responsible:** Slovenia; **Task:** Detection of regional kinematics in Austria, Slovenia, Croatia and Bosnia & H (Romania, Bulgaria) by epoch campaigns.

**Final output:** Computation of revised coordinates; Continuation of activities is proposed and expected.

**Work package 10.2:**

**Responsible: Romania; Task: Determination of the velocity of the tectonic units in the Vrancea region of Romania (Eastern Carpathians)**

**Final output: Establishment and densification of the Romanian GPS network; All details in Monograph “Geodynamic Studies in Romania-Vrancea Zone”, RGW No. 6 (81), 2006, 304 pages.**

**Work package 10.3:**

**Responsible: Hungary; Task: Integrated study of the present tectonics of the Pannonian Basin (geodetic and seismic) relying on all available geo-physical and geological data;**

**Better understanding of the ongoing tectonic processes; seismic hazard assessment.**

**Final output: GPS crust velocity map of PB; Strain rates and determination of areas of significant strain accumulation; Map of compared active deformation and seismic hazard; Publication in scientific journals. And: Crust velocity map of CEI; interpolated velocity field; velocity comparisons.**

**Work package 10.4:**

**Responsible: Croatia; Task: Surveying of the lakes bottom and their water surface using echo sounders and underwater modules that perform positioning by means of GPS and CCRE technology integration. Regular re-observation of GPS-network for geodynamical purposes.**

**Final output: Digital dynamic three-dimensional geodetic model of the lakes, travertine barriers and tributaries; Basis for future planning; deformation field and strain parameters enabling the prediction of the future of the lakes.**

**Work package 10.5:**

**Responsible: Slovakia, Poland; Task: Geodynamic studies and geoid investigations in the region of Tatra mountains based on GPS, gravimetric measurements and existing terrestrial geodetic data (mainly precise levelling).**

**Final output: Velocity and strain field of the Tatra mountains; Check of gravimetric quasi-geoid GMSQ05 (high quality); Densification of gravimetric measurements required.**

**Work package 10.6:**

**Responsible: Ukraine; Task: Geodynamic studies in the northern part of Carpathians, including monitoring of recent crust movements and construction of a comprehensive geodynamic model for Northern Carpathians.**

**Final output: Charts of spatial velocities and earth’s surface deformations in the Carpathian region; Geodynamic investigations in the area of Pip-Ivan Mount. See the basic publications described in WP 10.**

**Work package 10.7:**

**Responsible: Bulgaria; Task: Establishment of a representative picture of the recent geodynamics of the Balkan Peninsula; Assessment of the un-favourable influence of hazardous geodynamical processes, seismic risk, earth-crust movements etc.**

**Final output: Establishment of a Bulgarian GPS reference system; Details contained in the monograph “Geodynamics of the Balkan Peninsula”, RGW 5(80), 2006, 647 pages.**

## 5. FINAL REMARKS AND FUTURE ASPECTS

**Statement 1:** We all promised to continue the CERGOP-activities after the project end for at least one decade. It is the task of the CEGRN consortium to keep this promise.

**Statement 2:** In order to fulfil the final challenge of “prediction and hazard mitigation” we have to work in near real time (Question: What is near real time in the framework of geo-kinematics and geodynamics ?)

**Conclusion:** This “never ending story” must be continued, but in which sense ? CEI may be incorporated into a European scheme in the future. Should this challenge be continued by EU and/or on a national basis ? Is CEGRN important for the continuation of one basic reference network, are epoch stations important anymore ? What is the time span for epoch observations in addition to the work of permanent stations ?

The FP 5 EU project CERGOP-2/Environment continued the successful work of CERGOP-1 (1993 – 2001) and gave large impacts on the densification of CEGRN, promoted international cooperation and leaves, at present, a well working group. How to use this facility ?

- Maintenance of the present CEGRN, update of velocities and geo-kinematics on national and EU basis (see e.g. A. Caporali et al.)
- Improvement of national networks (e.g. Bosnia&H., Albania, etc.)
- Projects in the FP 7 program of EC (see e.g. D. Medak)
- Inclusion of GALILEO (see e.g. G. Manzoni)
- Combination with WEGENER (look for the next meeting in Darmstadt)
- Inclusion of tide gauges and altimeters (sea level change, currents, ...)
- What else and whom can we persuade to provide money for this very important work ?

The coordinator thanks all of the contractors and their collaborators for their dedicated work within the project.

The coordinator deplores that in total only 86.4 % of the money agreed by EC could be spent. 277.100 € could not be distributed (mainly by wrong interpretation during the first project year; partly my or EC fault ?).

The coordinator requests all participating agencies to continue this kind of projects at least for the next decade. Actually, the supervision of changes of the earth surface and of the environmental parameters cannot be stopped. It is a primary task of our mankind to abandon a suitable environment to our next generations and to do the best to preserve it.

Finally, the coordinator who retired end of 2006 wishes the best success for all members of CEI (may be another name in future). He will be at disposal (without any local support) during his last healthy years.

## LIST OF THE MAIN REFERENCES

Proceedings of the EGU G17 Symposium “Geodetic and Geodynamic Programmes of the CEI”; Nice, France, Apr. 6-11, 2003.

Reports on Geodesy, Warsaw University of Technology, No. 1(64),2003, 348 pages.



**Proceedings of the 2<sup>nd</sup> CERGOP-2 Working Conference and CEGRN Consortium Steering Committee meetings, Warsaw, Poland, Sep. 29-30, 2003.**

**Reports on Geodesy, Warsaw University of Technology, No. 3(66),2003, 148 pages.**

**Proceedings of the EGU G11 Symposium “Geodetic and Geodynamic Programmes of the CEI”; Nice, France, Apr. 25-30, 2004.**

**Reports on Geodesy, Warsaw University of Technology, No. 2(69),2004, 379 pages.**

**Proceedings of the 3<sup>rd</sup> CERGOP-2 Conference, Sofia, Bulgaria, Sep. 30-Oct 1. 2004.**

**Reports on Geodesy, Warsaw University of Technology, No. 4(71),2004, 245 pages.**

**Proceedings of the EGU G9 Symposium “Geodetic and Geodynamic Programmes of the CEI”; Vienna, Austria, Apr. 25-30, 2005.**

**Reports on Geodesy, Warsaw University of Technology, No. 2(73),2005, 352 pages.**

**Proceedings of the CERGOP-2/Environment Semi-annual Conference; Sarajevo, Bosnia&Herzegovina, Nov. 11-12, 2005.**

**Reports on Geodesy, Warsaw University of Technology, No. 4(75),2005, 228 pages.**

**Proceedings of the EGU G6 Symposium “Geodetic and Geodynamic Programmes of the CEI”; Vienna, Austria, Apr. 2-7, 2006.**

**Reports on Geodesy, Warsaw University of Technology, No. 1(76),2006, 314 pages.**

**Proceedings of the Final CERGOP-2/Environment; Graz, Austria, Jul. 13-14, 2006**

**Reports on Geodesy, Warsaw University of Technology, No. 3(78),2006, 305 pages.**

**Report on “Geodynamics of Central Europe”; Current status of geo-tectonic investigations in Central Europe (Work package WP.10), Sep. 2006.**

**Reports on Geodesy, Warsaw University of Technology, No. 4(79),2006, 461 pages.**

**Geodynamics of the Balkan Peninsula; Monograph compiled in the frame of the project CERGOP-2/Environment (WP 10.1 – WP 10.6)**

**Reports on Geodesy, Warsaw University of Technology, No. 5(80),2006, 647 pages.**

**Geodynamic Studies in Romania-Vrancea Zone; Monograph compiled in the frame of the project CERGOP-2/Environment (WP 10.2)**

**Reports on Geodesy, Warsaw University of Technology, No. 6(81),2006, 304 pages.**

**Proceedings of the EGU G11 Symposium “Geodetic and Geodynamic Programmes of the CEI”; Vienna, Austria, Apr. 15-19, 2007.**

**Reports on Geodesy, Warsaw University of Technology, No: 2 (83), 2007, 145 pages.**

